cases shrivelled and contracted, as when potass solution or decomposing seminal fluid is applied, thus showing that the substance of the broken down spermatozoa had passed to the yelk by endosmosis. These experiments were made at the same time with others made with portions of the same fluid which had not been triturated, and in which the spermatozoa were still active. In these instances fecundation was constantly effected, so that the conclusion deduced from these comparative trials was, that fecundation is not the result simply of the addition of the substance of the body of the spermatozoon to the egg, but primarily seems to be due to a force or dynamic power in the spermatozoon, which is lost when this body has ceased to give evidence of its retention of it, in its power of motion.

The author then proceeds to inquire whether these results do not justify our viewing the spermatozoon as the organ of a special form or condition of force in the animal structure? and states, as he has done on a former occasion (Proceedings, June 1851, p. 83), other grounds on which the hypothesis seems to be supported, pointing out that the spermatozoon, like muscle and nerve, has both general and special anatomical structure and special chemical composition; and that as we have been accustomed to regard the power of muscular contractility as a distinct force, or form of force, of the body,—the same view being held with regard to nerve, the properties of these two tissues being perfectly distinct from each other,—so it appears to be correct to view the property of the spermatic structure; which is not only perfectly distinct from either of these, but different from that of every other tissue in the organization, and is not exercised until the structure itself has been entirely separated from the body of which it originally formed a part.

2. "On the Functions of the Membrana Tympani, the Ossicles and Muscles of the Tympanum, and of the Eustachian Tube in the Human Ear, with an account of the Muscles of the Eustachian Tube and their action in different classes of Animals." By Joseph Toynbee, Esq., F.R.S. &c. Received June 15, 1852.

The author commences his paper by making some observations on the general arrangements of the *ossicula auditûs*. The malleus and incus being firmly connected together by ligaments, are considered as a single bone, forming an elastic arch, the anterior extremity of which is firmly attached to the Glasserian fissure, the posterior to the anterior part of the mastoid cells. This arch is kept steady by the actions of the tenser tympani. The movement of this arch is that of rotation; and it is effected by the tensor tympani muscle. When this muscle contracts, the lower part of the arch, consisting of the handle of the malleus and the long process of the incus, is drawn inwards; by this action the membrana tympani is rendered tense, and the stapes being pressed towards the cavity of the labyrinth, the fluid in the latter is compressed.

The anatomy and attachments of the *stapes* are next minutely described. The base of this bone, generally stated by writers on

the physiology of the ear as being attached to the margin of the *fenestra ovalis* by a simple membrane, *ligamentum annulare baseos stapidis*, is shown to possess some points of considerable interest. Instead of a simple margin to which the ligament above noticed is fixed, the base of the stapes is stated to present a circumferential surface for articulation with the *fenestra ovalis*. This circumferential surface, larger at the anterior and posterior extremities than in the middle, is covered by articular cartilage. The surface of the *fenestra ovalis*, to which the circumference of the base of the stapes is applied, is somewhat larger than that of the stapes. It is smooth, has a very compact structure, and is not covered by cartilage.

The base of the stapes is attached to the *fenestra ovalis* by two ligaments. The inner or vestibular ligament passes from the inner margin of the *fenestra ovalis* to the inner margin of the circumferential surface of the base of the stapes. The outer one passes from the outer margin of the *fenestra ovalis* to the corresponding margin of the stapes. These two circular ligaments leave between them a space which may be considered as an articular cavity; this cavity always containing a sufficient quantity of fluid to lubricate the articular surfaces of the bones.

The movements of the stapes are of two kinds, one being produced by the action of the *tensor tympani*, the other by the *stapedius* muscle. If the *tensor tympani* muscle be drawn in the direction of its course, while the cavity of the vestibule has been exposed to view, the base of the stapes will be observed to be slightly projected towards the cavity of the vestibule, and it returns to its normal position as soon as the muscle is left quiescent: the ligaments above described appear to be the organs whereby the stapes is again drawn outwards. In this movement the stapes may therefore be described as passing to and fro within the *fenestra ovalis*, as a piston does in a cylinder. The *second* movement of which the base of the stapes partakes is one of rotation, and it is effected by the stapedius muscle. To show this movement, it is requisite to perform one or two careful experiments. The stapedius muscle being exposed in its canal, while the stapes is left undisturbed in the tympanic cavity which has been laid open, if the muscle be drawn in the direction of its course, the anterior crus of the stapes is observed to move slightly outwards and backwards. In what manner the base of the stapes is affected during this movement of the crura it is difficult to decide, but it would appear probable that its anterior part is drawn outwards from the cavity of the vestibule while the posterior part is pressed inwards, though to a less extent. That the action of the stapedius muscle is to relax the fluid of the labyrinth, is however shown by the following experiment. The tympanic cavity and stapedius muscle being exposed to view, a section is to be made through the cochlea, a small portion of the *scala vestibuli* being left continuous with the cavity of the vestibule. If the stapedius muscle be now drawn in the direction of its course, the fluid in the cut extremity of the *scala vestibuli* is observed to recede slightly towards the vestibule, and it returns to its former position

as soon as the stapedius muscle is left quiet. A second action of the *stapedius* muscle is to act as a laxator of the *membrana tympani*, and it thus appears that the *stapedius* muscle is the antagonist of the *tensor tympani*; and it seems to be brought into action during the act of listening, while the *tensor tympani*, on the contrary, contracts when the ear has to be protected from any loud vibrations.

The next part of the paper is devoted to the consideration of the functions of the *membrana tympani*; which, besides the one usually ascribed to it, viz. of receiving the sonorous vibrations from the air and of conducting them to the chain of bones and thence to the labyrinth, the author considers to be as follows:—

1. To act in conjunction with the ossicles and muscles of the tympanum as the analogue of the iris in the eye, and to exclude from reception by the labyrinth, of such strong vibrations as would be injurious to its integrity; also, in exactly opposite circumstances, to receive the most faint undulations, which would not be perceived unless the *membrana tympani* were rendered less tense than is the case in ordinary circumstances. The former of the two duties is performed by the *tensor tympani* muscle, the latter by the *stapedius*. The *membrana tympani* is not only of use in preventing powerful sonorous vibrations from compressing too forcibly the expansion of the auditory nerve, but it also protects the labyrinth from the forcible pressure of air or of a foreign substance in the meatus, during a blow on the ear or the introduction of a solid body which presses against the *membrana tympani*.

2. The *membrana tympani* shuts out the air in the meatus from that in the tympanic cavity, and by this means an atmosphere of certain physical conditions is constantly kept in contact with the membranes between the tympanum and labyrinth.

The *second* part of the paper is devoted to the examination of the Eustachian tube in man and animals. Anatomists seem to have inferred that the Eustachian tubes in their natural state are constantly open, and that the air of the tympanic cavities is always continuous with that in the fauces. An examination of the guttural portion of the Eustachian tube in man and animals has led the author to conclude, that excepting during muscular effort, this orifice is always closed, and that the tympanum is a cavity distinct from the outer air. The agents whereby the Eustachian tubes are opened in the human subject, are the muscles of the palate, and it is by their action during the process of swallowing that the tubes are ordinarily opened. That the act of swallowing is the means whereby the Eustachian tubes are opened, is shown by some experiments of which the following may be cited. If the mouth and nose be closed during the act of swallowing, a sensation of fulness and distension is produced in the ears; this arises from the air, which is slightly compressed in the fauces, passing into and filling the tympanic cavities; upon removing the hand from the nose, it will be observed that this feeling of distension does not disappear, but remains until the act of deglutition is again performed, but while the nose is not closed; in this experiment the Eustachian tubes were opened during each act

of swallowing; but during the first act, while they were open, air was forced into the cavity of the tympanum by the contraction of the muscles of the fauces and pharynx, and the orifices were again closed, and remained so until the second act of swallowing, which opened the tube and allowed the air to escape. That the act of deglutition opens the Eustachian tubes, was inferred also from the custom usually adopted of swallowing while the descent in a diving-bell is performed; by this act the condensed air is allowed to enter the tympanum and the sensation of pain and pressure in the ears is avoided. The author then proceeds to show that the *tensor* and *levator palati* are the muscles which are attached to and open the Eustachian tubes in man, and the mode in which they act is pointed out.

The *third* part of the paper is devoted to the examination of the Eustachian tube in animals; and the author arrives at the conclusion, that in Mammalia, Birds, and those reptiles having a tympanic cavity, the Eustachian tubes, as in man, are closed excepting during muscular effort. In some *mammalia* the muscles opening the tubes are, as in man, those belonging to the palate; in others the function is performed by the superior constrictor of the pharynx. In *birds* it is shown that there is a single membranous tube into which the two osseous tubes open; this membranous tube is situated between, and intimately adherent to, the inner surface of each pterygoid muscle, and by which muscles the tube is opened.

The conclusion respecting the influence of the closed Eustachian tubes to which the author arrives, is that the function of hearing is best carried on while the tympanum is a closed cavity; that the analogy usually cited as existing between the ordinary musical instrument, the drum and the tympanum, to the effect that in each it is requisite for the air within to communicate freely with the outer air, is not correct. The view that the sonorous vibrations of the air in a closed tympanic cavity are more effective in impressing the membrane of the *fenestra rotunda* than when it is open to the outer air, is strengthened by the performance of the following experiment with the tuning-fork. If this instrument be made to vibrate by striking it against a firm solid, and if the handle be then placed in contact with the head, the sound at first loud, gradually becomes fainter, and soon ceases to be heard; if at the moment that it has ceased to be heard, a finger be placed over the tragus of one ear, and firmly pressed so as to close the external meatus from the outer air, the sound of the tuning-fork is again heard, and continues to be heard for some seconds; thus showing that the sonorous undulations existing in the external meatus are not sufficiently powerful to affect sensibly the *membrana tympani* until they are wholly confined by the walls of the tube when closed.

The leading results arrived at in the paper are as follows:—

1. That a principal function of the *membrana tympani* muscles and ossicles of the tympanum, is to act as the analogue of the iris in the eye.

2. That the *tensor tympani* muscle, by drawing tense the *membrana tympani*, and by compressing at the same time the fluid in the

labyrinth, protects the ear from the injurious influence of very powerful vibrations.

3. The stapedius muscle, by slightly relaxing the *membrana tympani* and the fluid of the labyrinth, places the ear in a position to be influenced by vibrations of a most delicate character.

4. Another function of the *membrana tympani* is to form part of the resonant walls of the closed tympanic cavity.

5. The guttural orifices of the Eustachian tubes are closed, and the tympanic cavities do not communicate with the cavity of the fauces excepting during certain muscular actions.

6. In man and some mammalia the Eustachian tubes are opened by the muscles of the palate, in other animals by the superior constrictor of the pharynx.

7. In birds there is a membranous tube common to the two osseous Eustachian tubes, and this common tube is opened by the action of the internal pterygoid muscles.

8. For the function of hearing to be perfect, it is requisite that the tympanic cavity should be closed from the outer air.

3. " An Experimental Inquiry undertaken with the view of ascertaining whether any, and what signs of current Force are manifested during the organic process of Secretion in living animals " (continued). By H. F. Baxter, Esq. Communicated by R. B. Todd, M. D., F.R.S. &c. Received April 30, 1852.

The present communication is a continuation of a series of experiments, the first part of which was published in the Phil. Trans. for the year 1848. The object is to show that the changes which occur during the organic process of secretion in living animals are accompanied with the manifestation of current force; and the principal facts upon which this conclusion is founded are the following:—

1st. It was found that when the electrodes of a galvanometer are brought into contact with the secreted product and the venous blood flowing from the same organ, an effect upon the needle is produced, indicating the venous blood to be *positive*. This fact was established in the liver, kidneys and mammary gland.

2ndly. The effect could not be referred to the heterogeneity of the fluids without assuming that the blood was *acid* and *combined* with the secreted product; nor could it be referred entirely to *thermo-electric* effects, inasmuch as the current varied in each organ, and was capable of traversing a liquid conductor. The effects, however, may be partly due to *catalytic actions on the combining power of platinum*; and this last supposition tended to confirm the opinion originally entertained by Wollaston, that the changes which occur during secretion are analogous to those which take place in the *decomposing* cell of a voltaic circle.

Without giving any definite opinion as to the lungs performing the office of a secreting organ, it was found, that when one electrode was in contact with the mucous surface, and the other in contact with the blood in the pulmonary veins, an effect occurred upon the needle indicating the blood (arterial) to be *positive*. This fact ap-